Contribution to the Bionomics of the Grape Leaffolder, *Desmia funeralis* (Hubner): A Laboratory Study with Field Observations

(Lepidoptera: Pyralidae)

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The grape leaffolder *Desmia funeralis* (Hubner), which occurs on wild grapes from southern Florida to Canada and from northeastern Mexico to the Atlantic seacoast was probably accidently introduced to California in the late 19th century (Doutt et al., 1969). Since its introduction, it has been a secondary pest of grapes in California, and in recent years has become an important pest in certain areas, particularly in the eastern San Joaquin Valley.

Barnes (1944) reported that in central California, the grape leaffolder completes three full generations per year. In favorable years, a partial fourth generation may occur. Little additional biological information concerning this insect is available. The present study was initiated to obtain life history information for use in developing pest management programs.

Methods and Materials

The insects were obtained from laboratory culture of the grape leaffolder reared on fresh grape leaves. The culture was maintained in one-gallon ice cream cartons at the San Joaquin Valley Agricultural Research and Extension Center, Parlier. An ample supply of fresh leaves was provided five times a week. Insects were reared under controlled laboratory conditions at 23.9° ± 1° C and about 35% ± 15%RH.

Eggs less than 24 hour old were obtained by placing fertilized females in ice cream cartons containing green grape shoots with two to five leaves. Mated females were released about 4 p.m. every afternoon and eggs were collected the following morning and were isolated in small plastic vials. Newly hatched larvae (less than 14 hours old) were isolated in small plastic vials supplied with about 10 one inch diameter circles of grape leaf. Observations were continued throughout the larval development and changes in the feeding habits, body measurements, molting and morphological appearance were recorded. After

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larvae pupated, they were again isolated in the small plastic vials for adult emergence. Adults were fed on a 10% sugar solution and their behavior, mating, and oviposition were observed in the laboratory. Egg production data were obtained from twice daily observations of freshly emerged pairs of adults in one-gallon ice cream cartons, provided with sugar solution and fresh grape leaves for feeding and oviposition, respectively. Oviposition preference experiments were conducted by releasing pairs of males and females in the ice cream cartons provided with different surfaces for oviposition.

Field studies utilized pheromone trap and sweep samples to estimate the number of generations and daily flight patterns of the grape leaffolder. Since the discovery of a sex pheromone in grape leaffolder (AliNiazee and Stafford, 1973), the virgin female traps have become an important survey tool for detecting low populations of this insect. Field trapping studies were conducted for six months (April 15th through October 18th) using closed sticky traps (AliNiazee and Stafford, 1971). Each trap was provided with one virgin female as a pheromone source. Virgin females were fed on a 10% sugar solution and changed twice per week. Average counts from three virgin female traps are reported in this paper.

The sweep samples were collected at two hour intervals on six consecutive days in August, 1971, using an insect net with 12 inch diameter rim. Ten sweep samples were collected in each of 4 different 0.25 acre blocks. Averages of ten samples are given in figure 9.

LABORATORY RESULTS

EGG STAGE: The eggs of the grape leaffolder are deposited singly, occasionally touching each other, but mostly with some space in between. In the laboratory, eggs were laid on both surfaces of the leaves, mostly along the veins and vein angles. Both surfaces of the Thompson seedless grape leaves were equally attractive for oviposition, perhaps because the surface pubescence is less prominent in this variety. In the laboratory, almost all eggs were deposited during the dark period of a 16 hr. light 8 hr. dark cycle. This indicates that in nature oviposition occurs predominantly during the evenings and nights.

Eggs are flat, shiny, mostly round to oval in shape, measuring 0.6 to 0.9 mm in length (Fig. 1). They are loosely attached to the leaf surface. The developmental period of the eggs is correlated with temperature. Observations during the summer of 1971 indicated that under natural conditions eggs hatch in about four to seven days depending upon the weather. Under laboratory conditions the average incubation

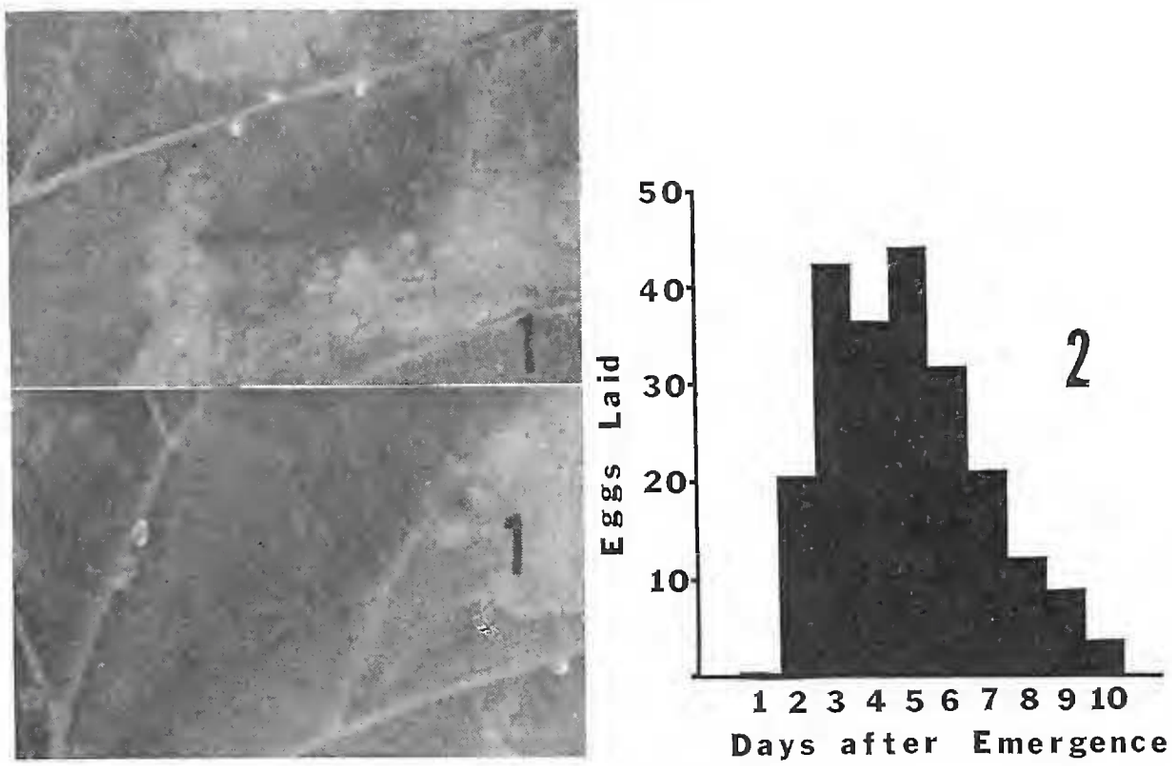


FIG. 1. Eggs of grape leaffolder. Fig. 2. Frequency of egg deposition by the grape leaffolder adults.

period was 5.3 days (range 3.5 to 9; n = 202) at 23.9 ± 1° C. About 84% of the eggs hatched within first eight days. Numbers of eggs laid by individual females varied from 6 to 431 (average 199; n = 24). A majority of the eggs were laid between the second and fifth day after emergence (Fig. 2). The average preoviposition period was 1.5 days, the oviposition period 6.7 days, and postoviposition period 1.3 days. Female moths failed to oviposit on a variety of artificial substances, including aluminum foil, plastic sheets and Saran® wrap, glass plates and smooth plywood sheets.

LARVAL STAGE: Soon after hatching, the young larvae move to protected places and feed by webbing two or more leaves, initially in groups. In the field, the leafrolls made by the earlier generations are preferred by young larvae. Laboratory observations indicate that young larvae feed between two leaves and do not make any leafrolls until they are about a week old. Initially, they make tiny leafrolls mostly towards the leaf edge and feed inside. As they grow the leafrolls are enlarged (Fig. 3) and by the time the larval development is complete, one or two leaves may be completely rolled. The density of rolls may be directly related to the population density of leaffolders. However, the ratio of rolls to stages of the insect varies with the date.

There are five larval instars. The developmental period of each instar

TABLE 1. Duration of the larval instars of the twenty-one grape leaffolder larvae reared on grape leaves at 23.9 ± 1° C.

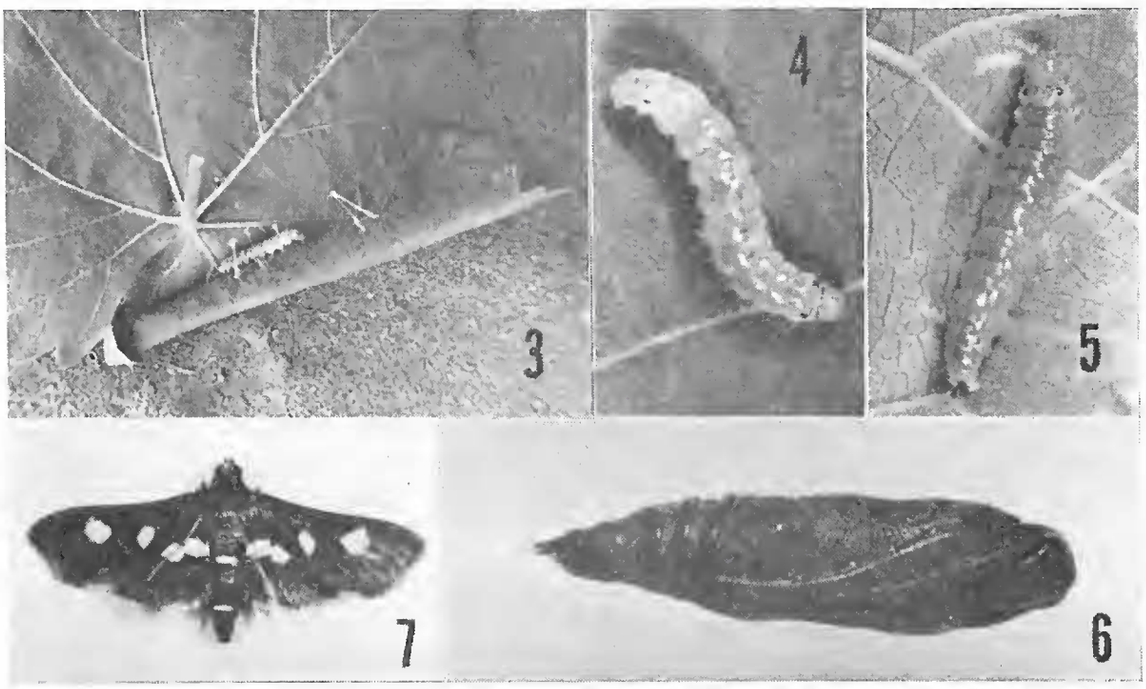
	Duration in Days		
Instar	Average	Maximum	Minimum
First	3.5	5.5	2
Second	3.9	5.5	2
Third	4.4	6	3
Fourth	4.3	7.5	3
Fifth	6.1	9	2.5

varies considerably depending upon the temperature. In the laboratory tests at 23.9 ± 1° C, the average developmental period of the first instar larvae was 3.5 days, the second instar 3.9 days, the third instar 4.4 days, the fourth instar 4.3 days, and the fifth instar 6.1 days (Table 1). The length of the larval period varied from 16 to 31 days with an average of 20.8 days.

Newly hatched larvae measure about 1.2 to 1.8 mm in length. They are creamy white to pale yellow. The second instar and older larvae are bright green to greenish-yellow. During development, the larvae develop characteristic markings that can be used to distinguish the different instars (Barnes 1944). The full grown larvae are light green and measure about 16–22 mm in length (Fig. 4). The larval feeding capacity varies in different instars and in vineyards of different varieties. Barnes (1944) reported that the larvae ate 3.34 square inches of Emperor grape foliage during their larval development. Out of this, less than 15% of the total foliage was eaten during the first three instars.

PREPUPAL AND PUPAL STAGES: After completing development, the larvae become quiescent before pupation. Towards the end of the fifth instar, larvae stop feeding and make a pocket-like case about ½ to ¾ inch long by cutting the leaves, or gluing the leaves together, and spend their prepupal and pupal stages in these envelopes. In almost all cases, a small piece of a grape leaf is cut on three sides and folded over to form an envelope. In the laboratory, paper towels which were put in rearing cages were similarly cut to form pupal cases. Sometimes, the envelopes are attached to other leaves. In the field, the envelopes fall to the ground with other foilage in late fall, and shelter the diapausing pupae until next spring.

During the prepupal stage, the larvae shrink considerably and the



FIGS. 3–7. Various instars of the grape leaffolder. Fig. 3. A leaf roll made by the grape leaffolder. Fig. 4. Mature larva. Fig. 5. Pre-pupa. Fig. 6. Pupa. Fig. 7. Adult.

body color changes from greenish-yellow to pink. Most of the prepupae observed were much fatter and shorter than the fifth instar larvae (Fig. 5). The prepupal period of 42 individuals observed in the laboratory varied from 2 to 6 days with an average of 2.7 days (Table 2).

Initially, the pupae of the grape leaffolder are light pink in color, but within a few hours after pupation they become dark brown. They

TABLE 2. The developmental period of different stages of the grape leaffolder reared on grape leaves at 23.9 ± 1° C.

Stage	Individuals Observed	Duration in Days		
		Average	Maximum	Minimum
Egg	202	5.3	9	3.5
Larval	43	20.8	31	16
Pre-pupal	42	2.7	6	2
Pupal	45	11.2	14	8
Egg to adult				
Males	32	39	54	32
Females	34	38.2	51	30
Both sexes	66	38.6	54	30

TABLE 3. Oviposition and longevity data of 22 to 26 mated grape leaffolder females maintained on sugar solution at 23.9 ± 1°C. All times in days.

	Pre-Oviposition Period	Oviposition Period	Post-Oviposition Period	Eggs/ Female	Adult longevity	
					Males	Females
Average	1.5	6.7	1.3	199	6.6	8.8
Maximum	2.5	13.5	2.5	431	12	15
Minimum	0.5	2.5	0	6	2	3

resemble the pupae of other pyralid moths and measure about 1 to 1.5 cm in length (Fig. 6). The pupal period of 45 individuals varied from 8 to 14 days, average 11.2 days (Table 2).

ADULT STAGE: Before adult emergence, the pupae wiggle vigorously and free themselves from the pocket-like pupal chamber. Soon after emergence, they move around quite a bit, probably in search of food. Under field conditions they hide in shady places underneath the vines during the daytime and begin their activities after sunset. They are medium sized black moths with patchy white spots on the body and wings (Fig. 7).

Adult longevity is dependent upon many factors including temperature and food availability. In the laboratory tests (Table 3), males fed on 10% sugar solution lived 2 to 12 days (average 6.6), while females lived 3 to 15 days (average 8.8). Adults fed on plain water did not survive as long; yet, they lived considerably longer than those provided with no water, which died in two to four days.

FIELD RESULTS

The field results were limited to study of adult behavior, daily rhythm and seasonal flight pattern.

Field observations indicate that one closed sticky trap with one virgin female as a pheromone source was much more effective than light traps. Results (Fig. 8) show that virgin female traps attracted enormous numbers of males during a five month season. Although the population of grape leaffolder varies from field to field and from year to year, the comparison of light trap catch data (AliNiazee and Stafford, 1972) with the catches of grape leaffolder in the virgin female traps definitely reflects the remarkable effectiveness of the sex pheromone traps. Also,

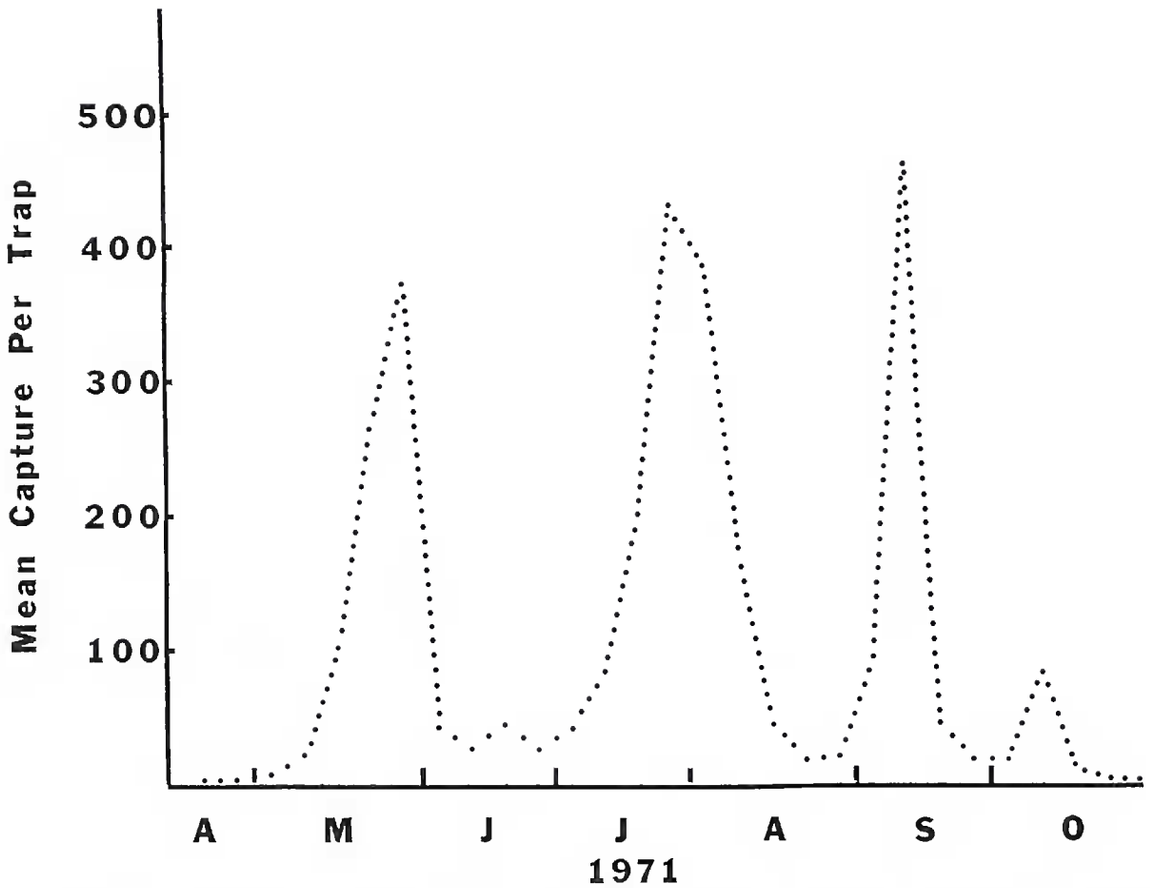


FIG. 8. Average number of adult males attracted to virgin female traps per week.

the virgin female traps were very effective in detecting low levels of moth activity.

Data presented in Figure 8 indicate that there were three population peaks during 1971. A relatively small peak occurred in October, which probably represented a partial fourth generation. The partial fourth generation may be a suicidal generation because of the lack of food availability and the onset of cold temperature regimes in late fall and early winter. Total numbers of moths collected per trap in each month of the study period indicate that the grape leaffolder population started at a lower level and then built up to a large population by the end of the season.

Adult activity during peak summer months, which determines the intensity and spread of vineyard infestations, was studied in central California vineyards. Field observations indicate that the grape leaffolder adults are nocturnal (Fig. 9). They begin their flight activity soon after sunset provided the temperature is not too high (above 32.3°C). However, the early evening flight activity is relatively insignificant. The activity increases with time, peaking about four to six hours after

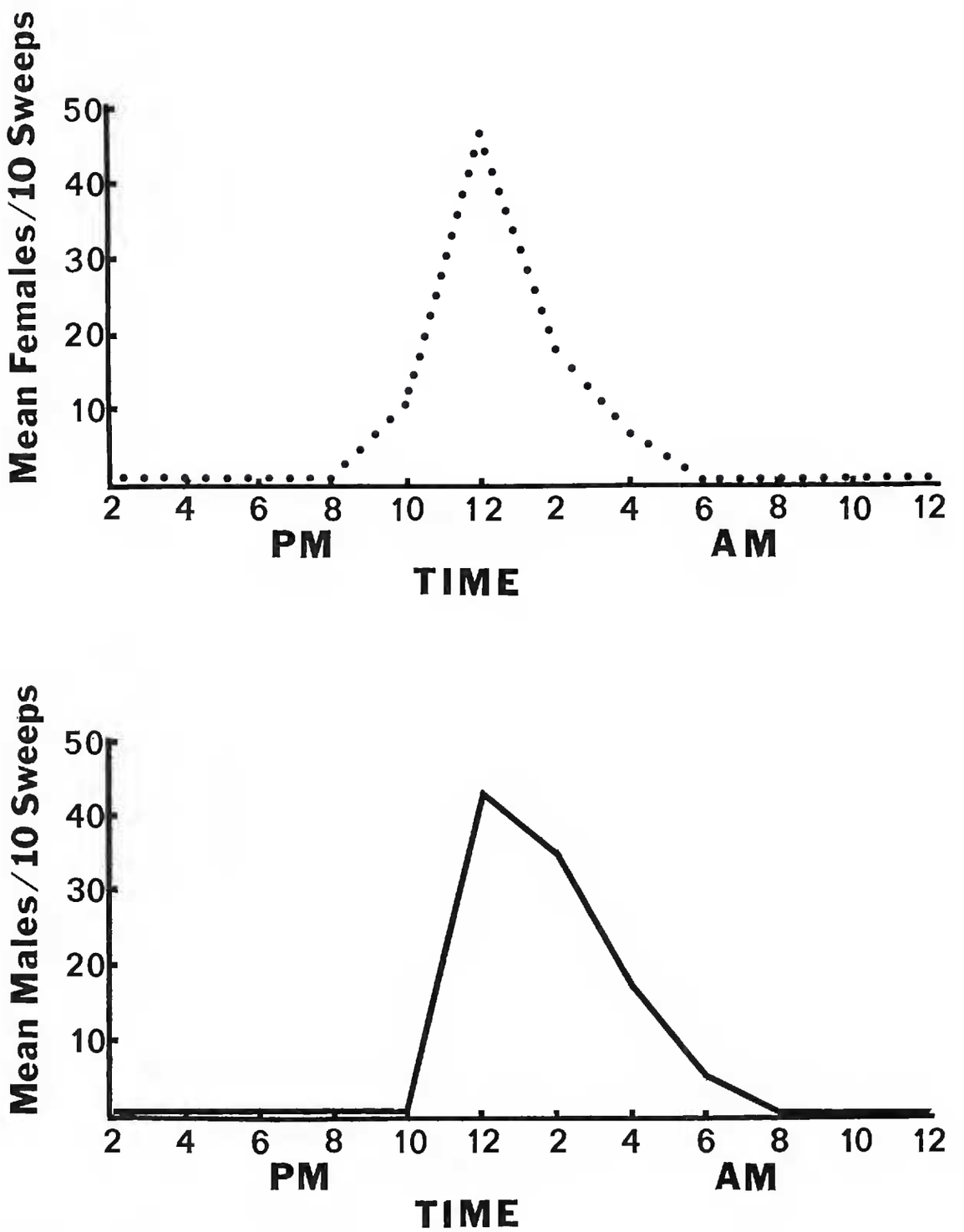


FIG. 9. Daily activity rhythm of males and females.

sunset. There were more females in the samples collected between sunset and midnight. However, about midnight the activity increased considerably and about equal number of males and females were collected in sweep net samples. Increased incidence of mating was observed about midnight and the early morning hours. At this time the male activity in the field increased and numbers of female decreased.

Adult activity continued until about 400 hours, but was mostly

dominated by the males toward the end (Fig. 9). The virgin female trap placed in the same vineyard revealed a similar situation. Male attraction to the female traps was very low for about two to four hours after sunset but increased sharply around midnight and continued until the next morning.

DISCUSSION

The oviposition record of 24 fertilized females indicates that most females started ovipositing on the second day after emergence, and a majority of them continued to oviposit until the seventh day. One female continued to oviposit until the 15th day after emergence. AliNiazee and Stafford (1973) showed that one-day-old virgin females were very attractive to males. This indicates that mating probably takes place within a day after emergence and the oviposition starts the next day.

There was little difference in the egg to adult period of males and females (Table 2). The egg-adult period of 66 grape leaffolders observed in the laboratory indicated a range of 30 to 54 days with an average of 38.6 days. The difference between the maximum and minimum length of development may explain the occasional occurrence of a partial fourth brood of the insect in the San Joaquin Valley vineyards. However, in spite of this 24-day difference in the maximum and minimum egg to adult development, a relatively high degree of uniformity of generation time is noted in the laboratory. This is also true in the vineyards where the overlapping of generations is a less severe problem than other grape insects such as the omnivorous leafroller, *Platynota stultana* (Walsingham).

The present study indicates that pheromone traps provide an improved method of monitoring activity and population fluctuations in these insects, as compared to, malt syrup traps (Barnes, 1944), light traps (AliNiazee and Stafford, 1972) or larval counts (Jensen, personal communication).

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ZOOLOGICAL NOMENCLATURE

ANNOUNCEMENT A. (N.S.) 92

Required six-months' notice is given of the possible use of the plenary powers by the International Commission on Zoological Nomenclature in connection with the following cases:

(See Bull. Zool. Nomencl. 30, parts 3/4, 28th June 1974)

1748. Suppression of *Scoptes* Hübner/1819/(Insecta, Lepidoptera)

2042. Designation of a neotype for *Apis rotundata* Fabricius, 1793 (Insecta, Hymenoptera)

2044. Designation of type-species for *Eriophyes* Siebold, 1851 and *Phytoptus* Dujardin, 1851 (Acarina, Eriophyoidea)

2046. Designation of a neotype for *Geloïus decorsei* I. Bolivar, 1905 (Insecta, Orthoptera)

2049. Designation of a type-species for *Lonomia* Walker, 1855 (Insecta, Lepidoptera)

2055. Validation of *Nysson* Latreille, 1796 (Insecta, Hymenoptera)

2056. Suppression of *Euplilis* Risso, 1826 (Insecta, Hymenoptera)

Comments should be sent in duplicate, citing case number, c/o British Museum (Natural History), Cromwell Road, LONDON S.W.7 5BD, England. Those received early enough will be published in the *Bulletin of Zoological Nomenclature*.—MARGARET GREEN Scientific Assistant